L Number	Hits	Search Text	DB	Time stamp
1	3	FORCE ADJ FEEDBACK SAME CURSOR SAME (SHAKE OR JITTER)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2002/06/28 06:31
2	43	FORCE ADJ FEEDBACK SAME FILTER	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2002/06/28 07:03
3	9	HAPTIC SAME FILTER	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2002/06/28 06:59
4	163	FORCE ADJ FEEDBACK SAME (VIBRAT$3 OR NOISE OR JITTER)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2002/06/28 07:51
6	117	IMMERSION$.AS.	USPAT; US-PGPUB	2002/06/28 07:59
7	7	IMMERSION$.AS. AND FILTER.CLM.	USPAT; US-PGPUB	2002/06/28 07:52
8	1	("6342880").PN.	USPAT	2002/06/28 08:06
10	1	(("6342880").PN.) AND FILTER	USPAT	2002/06/28 08:17
11	1	("6310605").PN.	USPAT	2002/06/28 08:18
12	1	(("6310605").PN.) AND REPORT	USPAT	2002/06/28 08:31
13	1	("5298918").PN.	USPAT	2002/06/28 08:32
14	1	("5742278").PN.	USPAT	2002/06/28 09:30
15	2711	((345/256) or (345/157) or (345/158) or (345/161) or (345/184) or (463/30) or (463/38) or (434/45) or (244/223) or (318/568.1) or (318/568.11)).CCLS.	USPAT	2002/06/28 09:31
16	347	(((345/256) or (345/157) or (345/158) or (345/161) or (345/184) or (463/30) or (463/38) or (434/45) or (244/223) or (318/568.1) or (318/568.11)).CCLS.) AND @PD>20010507	USPAT	2002/06/28 09:32
19	12	((((345/256) or (345/157) or (345/158) or (345/161) or (345/184) or (463/30) or (463/38) or (434/45) or (244/223) or (318/568.1) or (318/568.11)).CCLS.) AND @PD>20010507) AND @AD<19970414	USPAT	2002/06/28 09:33
-	1272	rosenberg,$.in.	USPAT	2002/06/27 09:03
-	77	rosenberg,$.in. and force adj feedback	USPAT	2002/06/27 09:58
-	1	rosenberg,$.in. and force adj feedback and disturbance.clm.	US-PGPUB	2002/06/27 09:05
-	4	(rosenberg,$.in. and force adj feedback) and disturbance.clm.	USPAT	2002/06/27 09:06
-	1127	force adj feedback	USPAT	2002/06/27 10:04
-	999	haptic	USPAT	2002/06/27 10:05
-	1954	(force adj feedback) or haptic	USPAT	2002/06/27 10:14
-	340	((force adj feedback) or haptic) and filter	USPAT	2002/06/27 10:16
-	111	((force adj feedback) or haptic) and force same filter	USPAT	2002/06/27 10:16

10/004,170

US-PAT-NO: 6067077
DOCUMENT-IDENTIFIER: US 6067077 A
TITLE: Position sensing for force feedback devices
DATE-ISSUED: May 23, 2000
INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
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US-CL-CURRENT: 345/161,463/38

CLAIMS:

What is claimed is:
1. A method for compensating for sensing inaccuracies contributed to by compliance in the mechanical systems of a force feedback device, the force feedback device being coupled to a host computer and including at least one actuator for outputting forces felt by said user, the method comprising:
reading a raw sensor value representing a position of a manipulandum of said force feedback device in a range of motion of said manipulandum, said manipulandum being physically contacted and manipulated by a user;
adjusting said raw sensor value based on a compliance of said force feedback device between a sensor and said manipulandum, said adjustment compensating for said compliance to provide a more accurate position of said manipulandum; and
using said adjusted sensor value to represent said position of said manipulandum.
2. A method as recited in claim 1 wherein said adjusting of said raw sensor value includes adjusting said raw sensor value by a value determined based on a compliance

see claim 28

claims 9, 26, 28

constant and a current output force, wherein said compliance constant is previously determined.

3. A method as recited in claim 1 further comprising using said raw sensor value for determining closed-loop position-dependent forces by said force feedback device, and wherein said adjusted sensor value is reported to said host computer to update an application program implemented by said host computer.

4. A method as recited in claim 3 wherein said position-dependent forces are determined by a microprocessor local to said interface device and separate from said host computer.

5. A method as recited in claim 1 wherein said sensor value is obtained from a sensor coupled to said actuator of said force feedback device.

6. A method as recited in claim 1 wherein said force feedback device includes a belt drive for transmitting forces from said actuator to said manipulandum.

7. A method as recited in claim 1 wherein a microprocessor separate from said host computer and local to said force feedback device performs said adjusting.

8. A method as recited in claim 7 wherein said adjusted sensor value is reported to said host computer as said position of said manipulandum, wherein said host computer uses said adjusted sensor value when updating an application program implemented by said host computer.

9. A method as recited in claim 1 further comprising filtering said raw value for overshoot sensor values occurring at limits to said range of motion of said manipulandum.

10. A method as recited in claim 1 further comprising dynamically calibrating said range of motion of said manipulandum by adjusting minimum and maximum values of said range of motion based on the extent of motion of said manipulandum up to a current point in time.

11. A method as recited in claim 1 wherein said manipulandum is a joystick and

wherein said joystick can be moved in two degrees of freedom, each of said degrees
of freedom providing a different raw sensor value to be adjusted.
12. A method as recited in claim 1 further comprising normalizing said raw sensor
value to a normalized range of motion, said normalizing including providing a
saturation zone at ends of said normalized range of motion that adjusts sensor
values over a saturation limit provided at said ends of said normalized range of
motion to a saturation level, wherein said normalized sensor value is provided to
said host computer.
13. A force feedback device coupled to a host computer, the force feedback device
comprising:
a manipulandum physically contacted and manipulable by a user;
a linkage mechanism providing a degree of freedom to said manipulandum;
at least one actuator coupled to said linkage mechanism, said actuator operative to
output a force on said manipulandum in said degree of freedom;
at least one sensor operative to sense a position of said manipulandum in said
degree of freedom and to output a raw sensor value representing said position; and
a local microprocessor, separate from and communicating with said host computer,
said local microprocessor receiving said raw sensor value from said sensor and
adjusting said raw sensor value based on a compliance between said sensor and said
manipulandum in said force feedback device, said adjustment compensating for said
compliance to provide a more accurate position of said manipulandum, and wherein
said local microprocessor outputs said adjusted sensor value to said host computer
as said position of said manipulandum.
14. A force feedback device as recited in claim 13 wherein said a linkage mechanism
providing said manipulandum with first and second rotary degrees of freedom, said
linkage mechanism and includes a chain of four

rotatably-coupled members coupled to
ground at each end of said chain.
15. A force feedback device as recited in claim 13 further comprising a belt drive
transmission coupled between said actuator and said linkage mechanism, said belt
drive transmission including a flat belt.
16. A force feedback device as recited in claim 15 wherein said manipulandum
includes a joystick.
17. A force feedback device as recited in claim 15 wherein said at least one sensor
is a relative digital encoder.
18. A force feedback device as recited in claim 13 wherein said at least one sensor
is coupled to said at least one actuator of said force feedback device such that
said sensor detects rotation of a shaft of said actuator.
19. A force feedback device as recited in claim 18 wherein said microprocessor
dynamically calibrates said range of motion of said manipulandum by adjusting
minimum and maximum values of said range of motion based on the extent of motion of
said manipulandum up to a current point in time.
20. A force feedback device as recited in claim 13 wherein said local
microprocessor uses said raw sensor value to determine closed-loop forces that are
dependent on a position of said user object.
21. A method for dynamically calibrating a sensed range of motion of a manipulandum
of a force feedback device, said force feedback device being coupled to a host
computer and including an actuator and at least one relative sensor, the method
comprising:
a) providing a predetermined initial range of movement for said manipulandum when
said force feedback device is initially powered, said initial range including two
boundary values, said boundary values including a maximum value and a minimum value;
b) receiving a sensor value representing a position of said manipulandum of said
force feedback device in said range of movement as said manipulandum is moved;
c) setting said maximum value or said minimum value to said

received sensor value if
said received sensor value is outside said initial range; and
d) adjusting said other of said boundary values not set in step c) to maintain said
initial range between said maximum value and said minimum value unless said other of
said boundary values has been previously detected to be outside said initial range.

22. A method as recited in claim 21 wherein said initial range is greater than zero
and is less than an entire physical range of motion of said manipulandum.

23. A method as recited in claim 22 wherein said initial range is about one-half an
approximate full range of said sensor.

24. A method as recited in claim 21 wherein said manipulandum is considered to be
positioned at about a center of said initial range of movement when said force
feedback device is initially powered.

25. A method as recited in claim 21 wherein said manipulandum is a joystick handle.

26. A method for providing accurate sensing of position of a manipulandum in a
force feedback device that includes compliance between said manipulandum and a
position sensor of said force feedback device, the force feedback device including
at least one actuator for outputting forces and being coupled to a host computer,
the method comprising:
reading a raw sensor value representing a position of a manipulandum of said force
feedback device in a range of motion of said manipulandum, said manipulandum being
phyisically contacted and manipulable by a user;
filtering said raw sensor value for overshoot sensor values occurring at limits to
said range of motion of said manipulandum; and
dynamically calibrating said range of motion of said manipulandum by adjusting
minimum and maximum values of said range of motion based on the extent of motion of
said manipulandum up to a current point in time, wherein said dynamic calibration
uses said filtered sensor values.

27. A method as recited in claim 26 further comprising

using said unfiltered raw
sensor values for determining a position of said manipulandum in said range of
motion.

28. A method as recited in claim 26 wherein said filtering includes using a low
pass filter on said raw sensor data.

29. A method as recited in claim 26 wherein said dynamically calibrating includes
assigning an initial range with initial maximum and initial minimum values to said
manipulandum.

30. A method as recited in claim 29 wherein said minimum and maximum values are
adjusted to keep said initial range between said minimum and maximum values until
both said minimum and maximum values are detected outside said initial range.

31. A method as recited in claim 29 wherein if said filtered sensor value is below
said minimum value, further comprising:
i) setting said minimum value to said filtered sensor value, and
ii) adjusting said maximum value to maintain a constant range from said minimum
value, unless said maximum value has previously been detected outside said initial
range.

32. A method as recited in clam 31 wherein if said filtered sensor value is above
said maximum value, further comprising:
i) setting a maximum value to said filtered sensor value; and
ii) adjusting said minimum value to maintain a constant range from said maximum
value, unless said minimum value has previously been detected outside said initial
range.

33. A method as recited in claim 26 further comprising adjusting said raw sensor
value based on a compliance of said force feedback device, said adjustment
compensating for said compliance to provide a more accurate position of said
manipulandum and reporting said adjusted sensor value as said position of said
manipulandum to said host computer.

34. A method as recited in claim 26 further comprising

normalizing said raw sensor
value to a normalized range, wherein said normalized value is reported to said host
computer.
35. A method as recited in claim 34 wherein said normalizing includes providing a
saturation zone at each limit of said normalized range, said saturation zone causing
said sensor values over a saturation level provided at said ends of said normalized
range of motion to be adjusted to said saturation level.
36. A method for compensating for sensing inaccuracies contributed to by compliance
in the mechanical systems of a force feedback device, the force feedback device
including at least one actuator for outputting forces and being coupled to a host
computer, the method comprising:
reading a raw sensor value representing a position of a manipulandum of said force
feedback device in a range of motion of said manipulandum, said manipulandum being
physically contacted and manipulable by a user;
normalizing said raw sensor value to a normalized range of motion, said normalizing
including providing a saturation zone at each end of said normalized range of motion
that adjusts sensor values over a saturation level provided at said ends of said
normalized range of motion to said saturation level; and
reporting said normalized sensor value to said host computer, wherein said host
computer updates an application program using said normalized sensor value.
37. A method as recited in claim 36 wherein said normalizing is provided according
to a normalizing function, said normalizing function being a linear function having
said saturation levels at said ends of said linear function, wherein said
normalizing function has a greater slope between said ends of said range of motion
than a normalizing function without said saturation zones.
38. A method as recited in claim 36 further comprising adjusting said raw sensor
value based on a compliance of said force feedback device, said adjustment
compensating for said compliance to provide a more accurate

position of said
manipulandum.
39. A method as recited in claim 38 wherein said adjusted sensor value is
normalized to said normalized range of motion and is reported to said host computer.
40. A method as recited in claim 39 wherein said raw sensor value is normalized to
said normalized range of motion and is used for local determination of forces by a
local microprocessor separate from said host computer.
41. A method as recited in claim 40 wherein said local determination of forces
includes determining a closed-loop condition force, said closed-loop condition force
including one of a spring force, a damping force, and a texture force.
42. A method as recited in claim 36 further comprising dynamically calibrating said
range of motion of said manipulandum by adjusting minimum and maximum values of said
range of motion based on the extent of motion of said manipulandum up to a current
point in time.
43. A method for dynamically calibrating a sensed range of motion of a manipulandum
of a force feedback device during usage of the device, said force feedback device
being coupled to a host computer and including an actuator and at least one sensor,
the method comprising:
providing a sensing range of motion for said manipulandum less than a full range of
motion of said manipulandum, said sensing range having a maximum value and a minimum
value;
reading a sensor value using said at least one sensor, said sensor value
representing a position of said manipulandum of said force feedback device
as said manipulandum is moved;
outputting a force on said manipulandum by said actuator approximately concurrently
with said reading of said sensor value;
setting said maximum value of said sensing range to said sensor value if said sensor
value is greater than said maximum value, wherein said maximum value is not set if

said force is being output in a direction towards a maximum physical limit past said
maximum value; and
setting said minimum value of said sensing range to said sensor value if said sensor
value is less than said minimum value, wherein said minimum value is not set if said
force is being output in a direction towards a minimum physical limit past said
minimum value.
44. A method as recited in claim 43 further comprising repeating said reading,
outputting and setting said values for a plurality of successive sensor values.

DOCUMENT-IDENTIFIER: US 6067077 A
TITLE: Position sensing for force feedback devices

---------- KWIC ---------

ASZZ:
Immersion Corporation

CLPR:
28. A method as recited in claim 26 wherein said filtering includes using a
low pass filter on said raw sensor data.

DOCUMENT-IDENTIFIER: US 5116180 A
TITLE: Human-in-the-loop machine control loop

---------- KWIC ---------

DEPR:
The bandwidth of the force feedback loop is only limited by the noise filter 121 and the sampling frequency of the measured force signals from the force/moment sensor 104. Thus, the force feedback response may be made sufficiently fast to reflect all humanly perceptible changes in the force.
Since a human hand can distinguish vibrations of up to about 10 Hertz, the bandwidth of the force feedback loop of this invention is chosen so as to reflect vibrations of at least this frequency.

DEPR:
The position signals from the potentiometers 131 of the hand controller input gravity compensation block 125 via the analogue to digital converter 103b. The output of the gravity compensator is summed with the force feedback signals at summing junction 120 and, hence, is fed back to the motors 130 of the hand controller via noise filter 121, summing junction 122, and power amplifier 123.
The gravity compensator, by way of an algorithm well known to those skilled in the art, provides a feedback signal which negatives the effects of gravity on the hand controller. Thus, acting alone, the gravity compensator makes the joystick seem weightless in the hands of an operator.

PGPUB-DOCUMENT-NUMBER: 20010045941
DOCUMENT-IDENTIFIER: US 20010045941 A1
TITLE: FORCE FEEDBACK SYSTEM INCLUDING MULTIPLE FORCE PROCESSORS

---------- KWIC ---------

CLTX:
31. A force feedback interface device as recited in claim 28 wherein said haptic accelerator includes a filter for rejecting spurious raw sensor signals.

Now U.S. Patent 6,342,880
Patent does not claim the filter.
JB
6/28/02

DOCUMENT-IDENTIFIER: US 5999168 A
TITLE: Haptic accelerator for force feedback computer peripherals

---------- KWIC ---------

CLPR:
30. A force feedback interface device as recited in claim 27 wherein said haptic accelerator includes a filter for rejecting spurious raw sensor signals.

claims 9, 30 and 38 filter